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WATERPROOF, BREATHABLE ARTICLES OF APPAREL

S P E C I F I C A T I O N

Background of the Invention

This is a Continuation-In-Part application of co-pending application Serial No. 09/384,938 filed August 27, 1999.

Field of the Invention

The present invention relates generally to articles of apparel. More particularly, the invention concerns improved articles of apparel used to cover the wearer's extremities such as an improved, waterproof sock that includes a novel sealing cuff and a body portion that will permit perspiration to transpire through the sock, but will keep water from external sources away from the wearer's foot.

Discussion of the Prior Art

Various attempts have been made in the past to produce breathable, waterproof articles of apparel such as gloves and socks that will keep the wearer's hands and feet dry and at the same time permit perspiration to transpire through the article. Materials, which will accomplish this desired function, have been known for sometime. Among the most successful waterproof, breathable articles of apparel ever developed are those developed by the present inventor and described in

United States Patent numbers 5,655,226, 5,483,703, and 4,942,214. Because of the pertinence of these patents to a complete understanding of the present inventions, patent numbers 5,655,226, 5,483,703 and 4,942,214 are incorporated by reference as though fully set forth herein.

The present invention constitutes an improvement in the articles described in the aforementioned patents. More particularly, the articles of apparel of the present invention include a novel sealing cuff arrangement that guards against water entering the interior of the article at a location between the cuff and the covered extremity.

As will be better appreciated from the discussion which follows, the present invention provides, for the first time, articles of clothing such as socks and gloves which exhibit the comfort and stretchability of traditional types of sport socks and gloves that include a waterproof body portion and a novel, sealable cuff that provides an article that is both breathable and completely waterproof.

Summary of the Invention

It is an object of the present invention to provide comfortable articles of apparel and the method of making the same which include a sealable cuff portion and a shaped body portion that will allow water vapor due to perspiration to transpire

through the article but will prevent water from external sources from reaching the wearer's extremities.

A particular object of the invention is to provide a footwear article of the aforementioned character which includes an elastic sealing cuff that seals against the user's leg and prevents the entry of water between the cuff and the user's leg.

Another object of the invention is to provide articles of the aforementioned character in which water vapor from perspiration can be transmitted from the inside to outside of the body portion so that the natural evaporative cooling effect can be achieved.

Another object of the invention is to provide a method of making articles of the character described in the preceding paragraphs which is simple and straight forward, does not require the use of complicated equipment and can be performed by unskilled workmen with a minimum of training.

A particular object of the invention is to provide a sock as described in the preceding paragraphs which is of simple construction, is lightweight, is pliant and durable in use, and is easy to manufacture.

In its preferred form, the footwear article of the invention comprises a sock having a sealable cuff portion and an interconnected body portion. The body portion is of three-ply construction with the inside and outside plies being knit and the intermediate ply being made from an elastomeric polyurethane film. The three

plies are uniquely bonded together using a pliant, waterproof adhesive. The sealable cuff portion is of a two-ply construction with the outside ply being an elastic knit and the inside ply being a continuation of the elastomeric polyurethane film of the body portion.

Brief Description of the Drawings

Figure 1 is a side-elevational view illustrating the method of making the footwear article of the invention and showing the components of the article in position over a foot-shaped planar mandrel.

Figure 2 is an enlarged, cross-sectional view taken along lines 2-2 of figure 1 showing the two-ply cuff construction.

Figure 3 is an enlarged, cross-sectional view taken along lines 3-3 of figure 1 showing the three-ply construction of the body portion.

Figure 4 is an enlarged, cross-sectional view taken along lines 4-4 of figure 1.

Figure 5 is an enlarged, fragmentary, cross-sectional, illustrative view showing the manner in which the sealable cuff portion of the sock sealably engages the user's leg.

Figure 6 is a generally perspective view of one form of the footwear article of the invention shown covering the foot and lower leg portion of the user.

Figure 7 is an enlarged, cross-sectional view taken along lines 7-7 of figure 6.

Figure 8 is a generally perspective view similar to figure 6 but showing the cuff portion of the footwear article folded down.

Figure 9 is an enlarged, cross-sectional view taken along lines 9-9 of figure 8.

Description of the Invention

Referring to the drawings and particularly to figures 1 through 4, one form of the article of apparel of the present invention is there shown. The article here comprises a sock construction including a thin, pliant bladder 12 constructed from a waterproof, breathable material, such as polyurethane sheet. The polyurethane sheet can be of various thicknesses as, for example, between about 1.0 mils and about 3.0 mils. Bladder 12 is of a first size and length and includes a lower body portion 14 and an upper cuff portion 16 (figure 4). Bladder 12 includes an outer surface 18 and an inner surface 20. Bladder 12 has the unique capability of generally conforming to the contours of the human foot and leg so that it can be comfortably worn inside a boot or shoe.

Bonded to the inner surface 20 of the elastomeric bladder is a lightweight covering member such as a first fabric inner sock 22 of standard construction, which is preferably made from knitted natural or synthetic fibers. Sock 22 is of a

second size smaller than said first size and a second length less than the first length of bladder 12 (figure 4).

The article of the invention also includes a second fabric outer sock 24, the body portion 24a of which is bonded to the outer surface of the body portion 14 of bladder 12. Body portion 24a can be constructed from filament or spun yarns as well as from natural fibers such as wool fibers, or from a variety of synthetic fibers such as polyester or nylon and combinations thereof. Outer sock 24 also includes an upper cuff portion 24b that embodies elastic fibers that impart elasticity to the cuff portion causing it to be continuously urged inwardly toward the covered extremity. The techniques for weaving the stretch and return cuff portion 24b are well understood by those skilled in the art and several elastic fibers such as a fiber sold by duPont under the name and style "LYCRA" can be used in conjunction with other fibers to form the cuff portion. It is to be observed that second, or outer sock 24 is of a third size larger than the first size of bladder 12 and has a third length greater than the second length of inner sock 20 and also greater than the first length of bladder 12. More particularly, as best seen in figures 4 and 5, the cuff portion of outer sock 24 preferably extends beyond the upper edge 12a of bladder 12 by a distance of about one-half inch.

Inner sock 22 and a portion of outer sock 24 are bonded to bladder 12 by means of a waterproof, heat activated adhesive. A hot melt adhesive in powder

form sold by Bostik, Middleton, Massachusetts, product #5116, a polyester type, has proven satisfactory for this purpose. Other adhesives can, of course, also be used, including a water-borne urethane heat activated, two-stage fluid adhesive sold by Stahl U.S.A. of Peabody, Massachusetts, under the designation UE-41742. In any event, the adhesive should be selected and applied in a manner that the breathability of the footwear is not destroyed or substantially reduced.

In the novel article of the present invention, the entire outer surface of the first sock 22 is securely bonded to bladder 12. However, as best seen in figures 4 and 5, the cuff, or upper portion 16 of bladder 12, has its outer surface securely bonded to the upper elastic cuff portion 24b of an outer sock 24. In a manner presently to be described, elastic cuff 24b uniquely functions to urge the inner surface of the bladder into sealing engagement with the user's leg.

The thin, pliant, thermoplastic material from which the waterproof, breathable bladder is made is of a character that will prevent penetration of liquid water while at the same time permitting free passage of moisture vapor such as perspiration. This material can be a polyurethane sometimes described as thermoplastic urethane. A suitable material of this type is sold by Fabrite Laminating Corp. of Woodridge, New Jersey. Other suitable materials include elastomers made from polyesters, copolyesters, polyamides, cellulose derivatives, polyacrylic acid and its holologs, natural or synthetic rubber with hydrophilic impurities, copolyozamides,

polyureas, polyelectrolytes, polyphosphates, polyvinylamid, polyvinylalcohol, polyether, and copolymers thereof, polythioether, polythioether-polyether, copolyepichlorohydrin-ether, polysulphosphates, copolyester-ether and derivatives or mixtures thereof.

Considering next the method of the invention, the thin, pliant bladder membrane is first coated with a light coating 27 of the hot melt adhesive to form a precursor, coated membrane. Next, the precursor, coated membrane is heated to a temperature slightly above the softening point of the adhesive, thereby causing the discrete particles of the adhesive which have been randomly deposited onto the bladder to fuse to the surface of the bladder material to form a coated membrane. Reference should be made to incorporated by reference patent No. 5,862,588 for a more detailed description of this adhesive deposition process.

The next step in one form of the method of the invention is the construction of the waterproof, breathable bladder. This is accomplished by overlaying two sheets of the previously described coated membrane and then to define on the membrane a line circumscribing the boundary of the bladder. This done, the sheets of coated membrane are heated along the boundary line to a temperature sufficient to sealably bond the membranes together along the boundary line. This heating-fusion step can be accomplished in several ways well known to those skilled in the art, including the techniques described in the incorporated by reference patents

5,655,226, 5,483,703 and 4,942,214. The heating-fusion step produces a bladder having a perimeter of a first size and length. As indicated in figures 1 and 5, the bladder 12 has an extremity-receiving portion that is in the general shape of the wearer's extremity.

As illustrated in figures 1 and 4 of the drawings, the next step in the method of the invention is to place the first covering member, or inner sock 22 over a generally foot-shaped, approximately 1/8th inch thick, generally planar mandrel 30 having smooth outer surfaces. Sock 22, which has inner and outer surfaces 22a and 22b (figure 3) is placed over the mandrel so that inner surface 22a thereof is disposed in engagement with the faces 30a of mandrel 30. As previously discussed, sock 22 can be constructed from a variety of materials and has a perimeter of a second size smaller than the size of the bladder and a second length less than the length of the bladder 12. For cold weather comfort, the inner sock can be made utilizing THERMAX® material made by E. I duPont de Nemours and Co. of Wilmington, Delaware. For warm weather comfort the inner sock can be made utilizing a COOLMAX® material made by duPont.

After sock 22 has been placed over mandrel 30 and smoothed out so that its inner surface 22a is in close engagement with the faces of the mandrel 30, a light coating 32 of adhesive is applied to the exposed surface 22b of sock 22 (figure 3). The adhesive can be applied to sock 22 by spraying, rolling, painting or in any

other customary way. This done, a first assemblage is formed by carefully placing bladder 12 over the assemblage of sock 22 and mandrel 30 and is smoothed so that the inner surface of the bladder is in close engagement with the adhesive coated sock 22. This first assemblage has a third size and shape as illustrated in the drawings.

Either before or after emplacement of the bladder onto the mandrel, a second covering member or sock 24 is emplaced over another mandrel and appropriately smoothed out. Second sock 24 has a perimeter of a fourth size larger than the size of the first assemblage and a third length greater than the second length of first sock 22. The exposed, or second surface of sock 24, is then coated with a layer 34 of adhesive and the adhesive is allowed to dry. The second sock is then removed from the mandrel, turned inside out and placed over bladder 12 which is mounted on the first mandrel 30 over first sock 22. With this arrangement, the adhesive coated, second side of sock 24 is in engagement with the exposed surface 18 of bladder 12 and the second, or precursor, assemblage thus formed has the configuration shown in figure 4. As can be seen in figure 4, the lower body portion of the precursor assemblage is three-ply while the upper cuff portion 24b is only two ply with bladder 12 extending a substantial distance above the upper margin 34 of inner sock 22.

The precursor assembly comprising the bonded together first adhesive coated sock 22, the bladder 12 and the second adhesive coated sock 24 is then heated and compressed in the manner described in the incorporated by reference patents 5,655,226; 5,483,703 and 4,942,214 to form the finished article. Briefly, this step is accomplished by placing the mandrel, upon which the precursor assembly is mounted, between two platens that can be controllably heated and urged together. During this temperature-pressure step, the polymer of the adhesive is cross linked making a permanent, waterproof bond of inner sock 22 to outside of the bladder and the outer sock 24 to the other side of the bladder.

Additionally, due to the unique design of the article of apparel of the invention, during the temperature, pressure step, portion 16 of bladder 12, that is the portion of the bladder extending above margin 34 of inner sock 22, is urged against the smooth surfaces 36 of mandrel 30 (figure 4). As the adhesive 27, which was previously deposited on bladder 12, melts and is pressed against the mandrel, it will melt to form a smooth surface that exhibits exceptional sealing capabilities.

After completion of the heating and compression step, the precursor assembly is removed from the press and allowed to cool thoroughly prior to doffing the completed waterproof footwear article from the mandrel. When removed from the mandrel, the footwear article is generally planar in shape and in one form of the invention, the article may be stitched along the margin of the bladder and the cuff.

In use, when the foot is inserted into the open cuff of the article, the foot engaging portion of the sock will neatly and smoothly conform to the shape of the wearer's foot.

Similarly, when the sock is in use, the elastic cuff portion 24b of the outer sock 24 exerts inward forces against the user's extremities as indicated by the arrows 35 in figure 5. These forces cause the glaze-like surface formed on the bladder to sealably press against the skin of the user forming a substantially water tight seal. As indicated in figure 5, even when the user's extremity "E" is submersed in water "W", this seal will prevent water from passing between the upper bladder portion 16 and the user's skin.

Turning to figures 6 and 7, a slightly different sock construction of the invention is shown in position over a user's foot and lower leg. This sock construction is substantially similar to that shown in figures 1 through 5 of the drawings and like numbers are used to identify like components. As before, the sock construction comprises a thin, pliant bladder 12 constructed from a waterproof, breathable material, such as polyurethane sheet (figure 7). Bladder 12 includes a lower body portion 14 and an upper cuff portion 16 and has an outer surface 18 and an inner surface 20. As earlier pointed out, bladder 12 has the unique capability of generally conforming to the contours of the human foot and leg so that it can be comfortably worn inside a boot or shoe.

Bonded to the inner surface 20 of the elastomeric bladder is a lightweight covering member such as a first fabric inner sock 22 of standard construction, which is preferably made from knitted natural or synthetic fibers (figure 7). Sock 22 is of a second size smaller than said first size and a second length less than the first length of bladder 12.

The article of the invention also includes a second fabric outer sock 40, the body portion 40a of which is bonded to the outer surface of the body portion 14 of bladder 12 in the manner previously described. Outer sock 40 also includes an upper cuff portion 40b that embodies elastic fibers that impart elasticity to the cuff portion causing it to be continuously urged inwardly toward the covered extremity in the manner indicated by the arrow 42 of figure 7. As in the earlier described embodiments outer sock 40 is of a third size larger than the first size of bladder 12 and has a third length greater than the second length of inner sock 20 and also greater than the first length of bladder 12. Also shown in figure 1, the cuff portion of outer sock 40 uniquely comprises a first or lower section 44 that is in overlaying engagement with bladder 12 and a second upper section 46 that extends beyond the upper edge 12a of bladder 12.

As before, the entire outer surface of the first sock 22 is securely bonded to bladder 12. However, as best seen in figure 7, the cuff, or upper portion 16 of bladder 12, has its outer surface securely bonded to the elastic cuff portion 44 of an

outer sock 40. With this construction, elastic cuff 44 uniquely functions to urge the inner surface of the bladder into sealing engagement with the user's leg "L" in the manner illustrated in figure 7 (see also figures 1 and 5).

If desired, the portion of the elastic cuff that extends beyond upper edge 12a of the bladder can be folded down in the manner shown in figures 8 and 9. When so folded down, additional forces are exerted on the bladder in the direction of the arrows 47 of figure 9 that tend to urge the bladder into sealing engagement with the user's leg "L". When the sock is in use, these inward forces cause the glaze-like surface 49 formed on the bladder portion 44 to sealably press against the skin of the user forming a substantially watertight seal. As previously mentioned, even when the user's foot and lower leg is submersed in water, this novel seal action will prevent water from passing between bladder portion 44 and the user's skin.

Having now described the invention in detail in accordance with the requirements of the patent statutes, those skilled in this art will have no difficulty making changes and modifications in the individual parts or their relative assembly in order to meet specific requirements or conditions. Such changes and modifications may be made without departing from the scope and spirit of the invention, as set forth in the following claims.